

**WHAT IS CLAIMED IS:**

- 1           1.       A method of generating a graphical bar code, comprising  
2           halftoning regions of an original image incorporating errors diffused among  
3           regions of the original image and computed based at least in part upon modulations  
4           in the graphical bar code corresponding to a graphical encoding of a message.
- 1           2.       The method of claim 1, wherein halftoning comprises computing  
2           quantization errors for respective regions of the graphical bar code.
- 1           3.       The method of claim 2, wherein the computed quantization errors are  
2           invariant to the graphically encoded message.
- 1           4.       The method of claim 3, wherein average block errors are diffused  
2           among regions of the original image.
- 1           5.       The method of claim 2, wherein halftoning comprises modifying  
2           original image regions with diffused errors to produce corresponding regions of a  
3           modified original image.
- 1           6.       The method of claim 5, further comprising applying a matrix-valued  
2           error filter to compute quantization errors to be diffused.
- 1           7.       The method of claim 5, wherein quantization errors are computed  
2           based at least in part upon a comparison of regions of the modified original image  
3           with corresponding regions of the graphical bar code.
- 1           8.       The method of claim 5, further comprising quantizing regions of the  
2           modified original image to produce corresponding regions of a base image.
- 1           9.       The method of claim 8, wherein quantizing comprises thresholding  
2           regions of the modified original image.

1           10.    The method of claim 9, wherein regions of the modified original image  
2   are thresholded at an intermediate gray level.

1           11.    The method of claim 8, wherein quantizing comprises assigning to  
2   regions of the base image respective representative quantized regions selected from a  
3   subset of possible representative halftone regions.

1           12.    The method of claim 11, wherein the subset of possible representative  
2   quantized regions consists of an all-dark representative quantized region and an all-  
3   bright representative quantized region.

1           13.    The method of claim 8, wherein regions of the base image are  
2   modulated with a graphical encoding of the message to produce corresponding  
3   regions of the graphical bar code.

1           14.    The method of claim 1, further comprising generating a sequence of  
2   graphical code words corresponding to a graphical encoding of the message.

1           15.    The method of claim 14, wherein halftoning comprises generating  
2   regions of a base image based upon propagation of errors to corresponding regions of  
3   the original image, and further comprising modulating regions of the base image  
4   based upon the sequence of graphical code words to produce corresponding regions  
5   of the graphical bar code.

1           16.    The method of claim 15, wherein modulating base image regions  
2   comprises applying an invertible graphical operation between regions of the base  
3   image and graphical code words.

1           17.    The method of claim 14, wherein one or more of the graphical code  
2   words are non-information-encoding and the remaining graphical code words are  
3   information-encoding.

1           18.    The method of claim 17, wherein information-encoding graphical code  
2 words and non-information encoding graphical code words are distinguishable on  
3 the basis of average gray value.

1           19.    The method of claim 18, wherein information-encoding graphical code  
2 words have gray values within a selected gray value range.

1           20.    The method of claim 17, wherein one or more non-information  
2 encoding graphical code words do not encode modulations into the graphical bar  
3 code during encoding.

1           21.    The method of claim 17, wherein one or more non-information  
2 encoding graphical code words visually enhance regions of the graphical bar code  
3 when encoded.

1           22.    A computer program for generating a graphical bar code, the computer  
2 program residing on a computer-readable medium and comprising computer-  
3 readable instructions for causing a computer to:

4                halftone regions of an original image incorporating errors diffused among  
5 regions of the original image and computed based at least in part upon modulations  
6 in the graphical bar code corresponding to a graphical encoding of a message.

1           23.    A method of decoding a graphical bar code, comprising:  
2                generating a base image having halftone regions representative of an original  
3 image;

4                probabilistically comparing regions of the base image to a set of graphical  
5 code words to obtain a sequence of graphical code words corresponding to a  
6 graphical encoding of a message; and

7                decoding the sequence of graphical code words to produce a decoded  
8 message.

1           24.    The method of claim 23, wherein the base image is generated by  
2 halftoning regions of the original image incorporating errors diffused among regions

3 of the original image and computed based at least in part upon modulations in the  
4 graphical bar code corresponding to a graphical encoding of a preselected message.

1 25. The method of claim 24, wherein the diffused errors are invariant to  
2 the graphically encoded message.

1 26. The method of claim 23, wherein the base image is generated without  
2 foreknowledge of the original image.

1 27. The method of claim 26, wherein generating the base image comprises:  
2 measuring one or more intrinsic features of the graphical bar code; and  
3 based upon the intrinsic feature measurements, selecting a sequence of  
4 halftone regions from a preselected set of halftone regions permitted to represent  
5 regions of the original image.

1 28. The method of claim 27, wherein selecting the sequence of  
2 representative halftone regions comprises selecting a representative halftone region  
3 for each region of the graphical bar code likely to match a corresponding region of  
4 the base image.

1 29. A computer program for decoding a graphical bar code, the computer  
2 program residing on a computer-readable medium and comprising computer-  
3 readable instructions for causing a computer to:  
4 generate a base image having halftone regions representative of an original  
5 image;  
6 probabilistically compare regions of the base image to a set of graphical code  
7 words to obtain a sequence of graphical code words corresponding to a graphical  
8 encoding of a message; and  
9 decode the sequence of graphical code words to produce a decoded message.